

**To:** Alberta Coal Policy Committee

**From:** Guy Gilron, Borealis Environmental Consulting Inc  
Gord McKenna, McKenna Geotechnical Inc

**Date:** 2021-06-07

**Subject:** **Written submission on selenium management**

## **1. Introduction**

Alberta's Coal Policy Committee invited Mr. Guy Gilron and Dr. Gord McKenna to provide an independent brief – in advance of discussions on June 9<sup>th</sup>, 2021 – regarding various aspects of selenium management at Rocky Mountain coal mines. Six questions were provided to Guy and Gord, for consideration prior to those discussions<sup>1</sup>.

As requested, we've provided background on our areas of expertise, a statement of our independence, and a statement regarding conflict of interest. Next, each of the questions is briefly addressed and we've followed up with recommendations to the Committee. We have also provided some high-level messages for your consideration. A short PowerPoint slide deck will be used to present this information to the Committee to support the discussion. Additional related information is presented in Gilron and McKenna (2021) and LDI (2021).

## **2. Expertise**

**GUY GILRON**, RPBio, MSc, BSc, ICD.D  
Senior Environmental Scientist, Independent Director  
Borealis Environmental Consulting Inc. North Vancouver, BC Canada

Guy Gilron has 30 years of experience in ecotoxicology and ecological and human health risk assessment relating specifically to anthropogenic effects on aquatic and terrestrial ecosystems. Guy has expertise in the development, evaluation and application of water quality guidelines and criteria in numerous jurisdictions in North America and beyond.



Prior to his work as Principal of Borealis Environmental, he served as VP Environment/Regulatory Affairs for Cardero Coal Ltd, and Director, Environmental Science for Teck Resources, based in Vancouver, BC, Canada. In the latter position, Guy contributed scientific input to the Elk Valley Selenium Task Force (EVSTF), a government/industry forum that addressed water quality issues and research in the Elk Valley downstream of Teck Coal mines. In addition to contributing to various research initiatives and publications related to selenium risk assessment, including "Ecological Assessment of Selenium in the Aquatic Environment" (Chapman *et al.*, 2010), Guy has played a key role in numerous multi-stakeholder working groups related to selenium assessment, management, and treatment, specifically: the EVSTF; the Canadian Industry Selenium Working Group; the Alberta Selenium Working Group; the North American Metal Council Selenium Working Group (NAMC-SWG),

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<sup>1</sup> As directed in an email from Fiona Salkie, Director, Coal Policy Secretariate dated 2021-06-02.

the latter for which he serves as Executive Secretariat; most recently, Guy has served as Science Advisor to the Coal Association of Canada, and several of its members, in support of proposed *Coal Mining Effluent Regulations* multi-stakeholder consultations. Guy has worked on various aspects of environmental aspects of the following representative coal projects:

Operating mines:

- Conuma Coal (Brule Mine) 2018-2020
- Teck Coal (Elk Valley Mines) 2006-2011

Development projects:

- Allegiance Coal (Tenas Project) 2017-2021
- Montem Resources (Tent Mountain) 2020-2021
- CanAus Coal / North Coal (Michel Creek) 2015-2018
- Cabin Ridge Project (with MGI) 2021
- Ram River Coal (Aries Project) 2019-2020

Closed coal mines:

- Smoky River Coal Mine / (sub to BGC) for AER 2017
- Bullmoose Mine for Teck Cominco 2004-2007
- Quintette Mine for Teck Cominco 2004-2007

As part of a multi-year effort by the NAMC-SWG, Guy has served as the technical lead for the group, evaluating various water quality guidelines/criteria and risk assessments for selenium. Guy has been involved as a technical reviewer of the Environment Canada and Health Canada Selenium Risk Assessment/Risk Management documents, the draft USEPA water quality criterion for selenium, and has prepared (together with GEI consultants and Windward Environmental) a state-of-science review of selenium guidelines and criteria in North America, on behalf of the American Petroleum Institute and the NAMC-SWG.

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**GORD MCKENNA** PhD, PEng, PGeol  
Geotechnical Engineer, Landform Designer,  
McKenna Geotechnical Inc. Delta, BC Canada



Gord McKenna is a geotechnical engineer and geologist who builds mining landforms and watersheds. He possesses over 30 years of experience in the mining industry in mine operations and as an international consultant for oil sands, coal, diamond, and metal mines, regulators, Indigenous peoples, and local communities. He is also an adjunct professor in the Civil and Environmental Engineering Department at the University of Alberta and the founding chair of the Landform Design Institute.

Gord and his teams have designed and built 23 reclaimed watersheds that cover 44 square kilometers and host 37 wetlands and 101 kilometres of streams. He has been a lead contributor to several manuals involving landform design, mine reclamation, and tailings, has co-authored 100 technical papers, and led over 40 landform design courses. He sits on eight geotechnical / tailings review boards across Canada.

Gord was a member of the Strategic Advisory Panel on Selenium Management (2010–2012) and has been involved with supporting research and designing mining landforms to manage selenium, working with numerous Rocky Mountain coal mines and local communities.

Gord has worked on the following coal projects:

- WCC Wolverine Coal geotechnical design (Norwest) 2004-2006
- Teck Cardinal River / Cheviot reclamation audit (Norwest) 2006
- Strategic Advisory Panel for Selenium Management (BGC) 2010-2012
- Teck Coal R&D / landform design (BGC/MGI) 2013-2020
- Coal Valley geotechnical design (BGC) 2013
- CanAus Coal / North Coal landform design (BGC/MGI) 2015-2021
- AER Smoky River Coal / (BGC/MGI/Borealis) geo-environmental investigation 2017
- Livingstone Landowners Group (MGI) engineering review 2019-2020
- Cabin Ridge (MGI/Borealis) Project selenium position paper 2021
- TransAlta Keephills Ash Lagoon (KCB/MGI) landform design 2021

Gord worked on behalf of the Livingstone Landowners from 2019 to 2020 reviewing the engineering / landform design aspects of the proposed Benga Grassy Mountain Coal Project and appeared before the Joint Review Panel as an expert witness.

[www.mckennageotechnical.com](http://www.mckennageotechnical.com)

[www.landformdesign.com](http://www.landformdesign.com)

[www.gordmckenna.com](http://www.gordmckenna.com)



**McKENNA GEOTECHNICAL**

### 3. Independence

**Guy Gilron** and **Gord McKenna** are independent professional technical consultants who work for the mining industry, various associations, Indigenous communities, local communities, and regulators in Canada and internationally.

**Mr. Gilron** founded Borealis Environmental Consulting Inc. (Borealis) to generate, apply and integrate scientific data, information, and principles to inform environmental policy and management. Since Borealis' inception in 2013, Guy's work has been categorized as follows: 70% related to coal, metal mines, oil sands projects in Canada and internationally, 15% for industry associations and multi-stakeholder forums, and about 15% (volunteer/professional) as: a Senior Editor of an International Scientific Journal (*Integrated Environmental Assessment and Management*); and, as a Board Member/Vice President for the non-profit organizations, Wildlife Preservation Canada, and the Canadian Ecotoxicity Workshop.

Guy is a Registered Professional Biologist (RPBio; accredited by the British Columbia College of Applied Biology (CAB)) with reciprocity with the Alberta Society of Professional Biologists and the United Kingdom Society of Biology. Mr. Gilron has 'right to practice' in British Columbia under the newly-enacted *Professional Governance Act*. As an RPBio, Guy adheres to the CAB Code of Ethics, which includes requirements for professional practice, including objectivity and independence when providing evidence or testimony.

The majority of Guy's work at Borealis relates to the use of science in supporting the environmental sustainability of mining industry projects. The consulting industry in this field of practice is relatively small; consulting scientists rely on their integrity and professionalism, and accreditation holds them to account for protecting the public. Mr. Gilron's scientific publications (including peer-reviewed journal articles, conference proceedings, book chapters and contributions to regulatory consultations and guidance documents), his work as the Executive Secretariat of the multi-stakeholder North American Metals Council – Selenium Working Group, and his other volunteer work, together provide a profile of a well-recognized and balanced professional. As is the case with Dr. McKenna, Guy seeks to support common vision among diverse stakeholders, sustainable resource use, and socio-economically viable coal mining.

**Dr. McKenna** founded McKenna Geotechnical partly to be able to provide independent advice to clients. Since inception in 2017, about 5% of its work is landform design for coal mines, about 5% for Indigenous and local communities, and 2% for regulators (contributing to technical guides). About 70% of his work is for oil sands, diamond, and metal mines in Canada and internationally, and about 20% (volunteer) for the University of Alberta, other universities, and for the Landform Design Institute.

Gord is a professional engineer and geologist registered with the Association of Professional Engineers and Geoscientists of Alberta). McKenna Geotechnical Inc. has an APEGA permit to practice in Alberta. The following is extracted from the APEGA code of ethics:

- "Professional engineers and geoscientists shall recognize that professional ethics is founded upon integrity, competence, dignity and devotion to service. This concept shall guide their conduct at all times....
- Professional engineers and geoscientists shall, in their areas of practice, hold paramount the health, safety and welfare of the public and have regard for the environment....
- Professional engineers and geoscientists shall conduct themselves with integrity, honesty, fairness and objectivity in their professional activities."

Given that Gord does most of his work for the mining industry, some can argue that there is a potential conflict of interest. And the geotechnical consulting industry is small enough that few practitioners are truly independent. However, Gord's publications (through the University of Alberta, various conferences, textbook chapters and design guides, the recent work for Livingstone Landowners and presentation to the JRP, his review work for First Nations, his work on the Selenium Panel, and his work and publications through the Landform Design Institute) paint a broader view. Gord seeks to help the various parties set common visions, and "mine with the end in mind" to jointly achieve successful reclamation paints a more balanced approach, for which he is known.

#### **4. Declaration of perceived conflicts of interest relating to this issue**

We disclose the following activities pertaining to the Coal Policy Committee (the Committee) discussions, to ensure transparency to the Committee:

1. Guy was invited by the Committee (through a recommendation from Robert Bell of Montem Resources and Robin Campbell of the Coal Association of Canada) to appear before them as an independent scientist with expertise in selenium management.
2. Gord was invited by the Committee to appear before them as an independent scientist with expertise in landform design as it relates to mine design and its use in selenium mitigation techniques.
3. In May 2021, Guy and Gord were retained by the Cabin Ridge Project to develop a White Paper on the state of practice for selenium management for two purposes: submission to the Coal Policy Committee; and, to guide Cabin River Project's mine design. Cabin Ridge has asked us to appear with them, at a separate time, before the Committee.
4. Gord has been invited by Livingstone Landowners Group to appear before the Committee as an independent expert to highlight issues he presented to the Joint Review Panel for Benga's Grassy Mountain Project.
5. Guy was invited by the Coal Association of Canada to appear before the Committee as an independent expert to support discussions related to water quality, selenium management, ecological and human health impacts, and water treatment technologies.
6. Guy was invited by Ram River Coal to appear before the Committee as an independent expert to support discussions related to water quality, selenium management and water treatment technologies.
7. Guy and Gord were both recently interviewed by Bob Weber of The Canadian Press and – based on this interview - an article on Alberta coal mine reclamation and selenium management appeared in Canadian newspapers in May of 2021 (e.g., <https://www.cbc.ca/news/canada/calgary/coal-mines-alberta-environment-community-1.60381030>).

## QUESTIONS and ANSWERS

### 5. What are the current world practices (standards) (best available technologies or practices) for managing selenium contamination as a result of surface coal mine activities?

Selenium is an issue in some areas with respect to agricultural runoff and mine waste as well as some wastewater treatment plant effluents. There are issues related to atmospheric deposition, vegetation uptake in reclaimed mine lands, and in waters downstream of metal mines, coal mines, and power generating stations. The following are areas in which selenium is elevated in waters downstream of operations: Alaskan metal mines, BC metal mines, BC/AB coal mines, Chinese coal mines, eastern US coal mines, US phosphate mines, and US and SK uranium mines. There are likely other regions with mine waste selenium issues that a cursory review did not reveal.

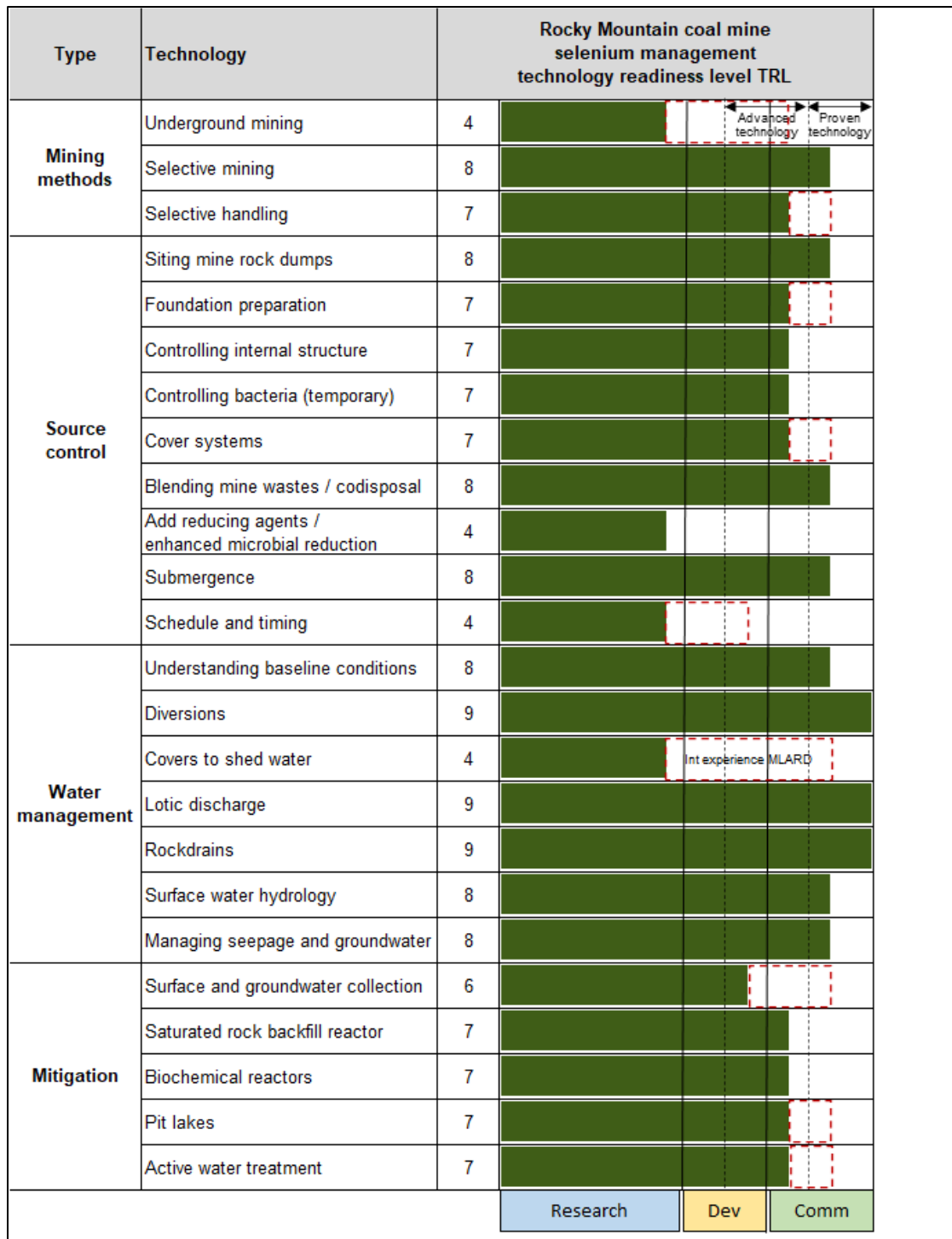
A review of the selenium management state of practice for Rocky Mountain coal mines in British Columbia and Alberta was recently completed by Gilron and McKenna (2021). Based on this review, the general approach employed by the sector is one of multiple-line-of defense, as part of a mine design / landform design process. Figure 1 provides a summary of the technologies employed under four categories – selective mining and handling, source control, water management, and mitigation.

A full international review of selenium management has not yet been conducted; however, the Electric Power Research Institute (EPRI) holds a biennial “Selenium Summit”, which explores the state of the science for selenium treatment (<https://www.epri.com/events/E53440E6-BEC4-43AF-9072-B709BDE0EF23>). A cursory review reveals that the geology and production of selenium is well understood (see Stillings 2017), especially for US geography.

With respect to the mining sector, the cursory review indicates that outside of northeast and southeast BC and Rocky Mountain coal mining, the main selenium management strategies employed are mitigations (e.g., collection of surface water and the use of active and semi-passive water treatment technologies). There are several vendors who supply commercial-scale active water treatment plants for selenium; several mines use semi-passive pit lakes, wetlands, and buried bioreactors to reduce selenium concentrations in runoff water. Much of the literature relates to court cases pertaining to exceedances of selenium water quality guidelines/criteria in downstream waters and the use of various selenium water treatment technologies. Golder (2020) was commissioned by the North American Metals Council Selenium Working Group to provide the most up-to-date review of selenium treatment technologies; their document details what is considered the current state of practice for water treatment.

Technologies for controlling metal leaching and acid rock drainage from hardrock mines are very similar to those being employed for selenium management. There is a rich literature based on decades of implementation at thousands of mines (INAP 2014) with practices and experience now being applied to Rocky Mountain coal mines for selenium management.

**Our recommendation:** The Government of Alberta should set out specific expectations for coal mines with regard to selenium management; this should include recognizing differences between historical/abandoned mines, proposed mines, existing mines, and closed mines. For each abandoned mine in the province, the Government of Alberta should determine which selenium management methods should be applied, and expedite implementation to meet the mine’s EPEA permit goals/objectives/compliance criteria.



**Figure 1. Technology Readiness Level for Rocky Mountain coal mine selenium management (adapted Gilron and McKenna, 2021)<sup>2</sup>**

<sup>2</sup> Details of the technology readiness scoring are available in Gilron and McKenna (2021). The assessment tool has been adapted from NASA (2017). Dashed red extensions to the green bars indicate where metal leaching / acid rock drainage technology employed internationally exceeds that for selenium management at Rocky Mountain coal mines.

## 6. How is selenium monitored in surface and groundwater on and adjacent to coal mines?

Selenium is monitored at coal mines to varying degrees and for various purposes on, and adjacent to, mine sites (including operations or closed/dormant properties). The extent and intensity of these monitoring programs are related to the overall magnitude of exceedances of selenium in water on site, and, more importantly, leaving the site. This includes both surface water and groundwater, although there has generally been a stronger focus on surface water discharges.

The three major purposes for monitoring selenium in water are: understanding site water balance, research and development, and regulatory compliance. The approach and design of these monitoring programs will align specifically to the purposes listed above. For example, understanding site water balance is crucial for assessing the success and efficacy of any mitigations applied at the site; design of the monitoring program temporally (i.e., sampling frequency) and spatially (i.e., sampling locations) will be dictated mainly by site precipitation, topography and hydrology, and the location of mine rockpiles. Monitoring for research and development purposes is usually related to the evaluation of selenium mitigation strategies (e.g., passive treatment system, such as wetland or bioreactor; efficiency of saturated rock fills, cover performance, etc.). Finally, for regulatory compliance, monitoring is usually more 'prescribed', generally dictated by effluent permits; specifically, selenium is monitored routinely at final discharge point(s) ("end of pipe") and/or varying distances downstream of the discharge, beyond the initial dilution zone (usually several sampling locations). The data from the latter monitoring type are used to determine compliance with regulatory effluent limits, site-specific water quality objectives, and ambient water quality guidelines<sup>3</sup>.

Groundwater quality (i.e., selenium concentrations in groundwater) is routinely monitored as part of the above-mentioned programs at mine sites, primarily to understand the relative proportion of aqueous selenium leaving a site that seeps into groundwater vs surface water runoff. The level of detail with respect to the spatial resolution of groundwater wells (for compliance) is inconsistent, and is generally not standardized.

Overall, the monitoring of aqueous selenium concentrations in surface water and groundwater should be considered "standard practice" across all coal mines (operating and closed) in Canada. Based on the recent focus on reducing selenium loadings and concentrations downstream of these coal mines, monitoring programs are becoming more comprehensive, and the resulting data are being used to understand, and more effectively manage, selenium.

See the recommendation that follows the next question below.

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<sup>3</sup>Currently these are provincial, and site specific; federal *Coal Mining Effluent Regulation* limits are being proposed, but are not yet in place.



**7. What monitoring information is currently available for selenium in our river systems downstream from active and historic coal mining projects? Is selenium being monitored from the outflows from current and former underground and surface coal mines in the province?**

To the best of our knowledge, the only consistent monitoring information/data (water quality sampling and analysis) available with respect to aqueous selenium in river systems downstream of mines-in-development, active/operating coal mines, and closed or historic properties, comes from proponent companies (i.e., those conducting baseline studies, operating mines monitoring per permit requirements, and those managing dormant sites, post-closure). All of the above-mentioned activities are conducted according to specifications in *EPEA*<sup>2</sup> permits, are reported to Alberta Environment and Parks (AEP), and are publicly-available (however, they are likely to require *Freedom of Information Act* requests).

From our understanding, while sampling and analysis can be and are carried out by both provincial (i.e., Alberta Environment and Parks (AEP), Alberta Energy Regulator (AER)) and federal (Environment and Climate Change Canada; ECCC) enforcement officers visiting mines for environmental compliance inspections, there are no regular, routine monitoring programs conducted by either federal or provincial departments/ministries.

Cumulative effect watershed monitoring programs (either industry- or regulatory-driven), similar to the Regional Aquatics Monitoring Program (RAMP; <http://www.ramp-alberta.org/ramp.aspx>) applied in the Oil Sands region of Alberta, have not been established or implemented for water bodies downstream of active or historic coal mines.

**Our recommendation:** AEP should be consulted for an update specific to selenium monitoring in Alberta rivers and lakes in the vicinity of coal mines.

**Our recommendation:** That the Alberta Government promptly establish an integrated regional aquatic monitoring program for the Eastern Slopes that includes a formal water-quality sampling component with a database that is accessible on-line shortly after these data are collected. The program should also monitor fish tissue (and other biota) relative to selenium. The monitoring should be designed, carried out, and analyzed in collaboration with the mines, local communities, and Indigenous Peoples. The database and associated analyses should include surface water and groundwater sampling results from compliance monitoring by individual mines. The sampling should complement data from existing stream-flow measurement stations. Most importantly, this work should be linked to the Alberta Coal Policy.

**8. Must a selenium management and mitigation plans be filed for current coal mining proposals? Are there standard conditions for handling selenium that must be applied to approvals for coalmines?**

Yes. While selenium management and mitigation plans (SeMMP) have only recently (i.e., in the last 5-10 years) become a requirement for coal mines, it is currently an expectation that new coal mine proposals include SeMMPs for the purposes of: evaluating project sustainability (feasibility study), obtaining environmental assessment (EA) certificates, and, ultimately, for mine permitting (in Alberta (AB), under *EPEA*<sup>4</sup> permits; in British Columbia (BC), *Mines Act* permits). The development of SeMMPs are usually preceded by what is referred to as a “Selenium Management Options Analysis”, the purpose of which is to evaluate the site-specific opportunities for managing/mitigating/treating selenium. Some examples: a given mine’s location and site topography may make it difficult to establish a wetland or bioreactor; a pit lake could not be part of an underground mine, in a situation where an open pit is not available; active treatment (and associated cost and infrastructure) is not justified, given the magnitude of exceedance of selenium.

An example table of contents of a standardized SeMMP is provided below:

1.0	INTRODUCTION
2.0	REGULATORY FRAMEWORK
3.0	CURRENT CONDITIONS
4.0	SELENIUM CONCENTRATION PREDICTIONS
5.0	WATER QUALITY OBJECTIVES FOR SELENIUM
6.0	SELENIUM MANAGEMENT ACTIVITIES
7.0	AQUATIC ENVIRONMENTAL MONITORING PROGRAM
8.0	RECORD KEEPING AND REPORTING
9.0	ADAPTIVE MANAGEMENT
10.0	REFERENCES

APPENDICES

Appendix A	Water Quality Sampling Results
Appendix B	Selenium Management Options Analysis
Appendix C	Conceptual Water Management Design
Appendix D	Hydrology Report
Appendix E	Selenium Load Balance Model
Appendix F	Selenium Source Terms

SeMMPs are often linked to other aspects of site environmental management plans, including: site water management (dealing with other chemicals of concern, potential acid rock drainage), explosives management (since nitrate can often be co-treated with selenium), and calcite management. For this and other reasons (e.g., sensitivity of downstream receptors), it is crucial to develop an integrated approach to site water management, which includes the management of selenium.

At some mines, given the potential for long-term semi-passive or active treatment of selenium after mine closure, SeMMPs are more often linked to the financial security bond for a mine (e.g., MFSP<sup>5</sup> in Alberta), given the potential significant expenditures associated with active selenium treatment systems and other non-treatment system mitigations (e.g., reclamation/development/monitoring of pit lakes).

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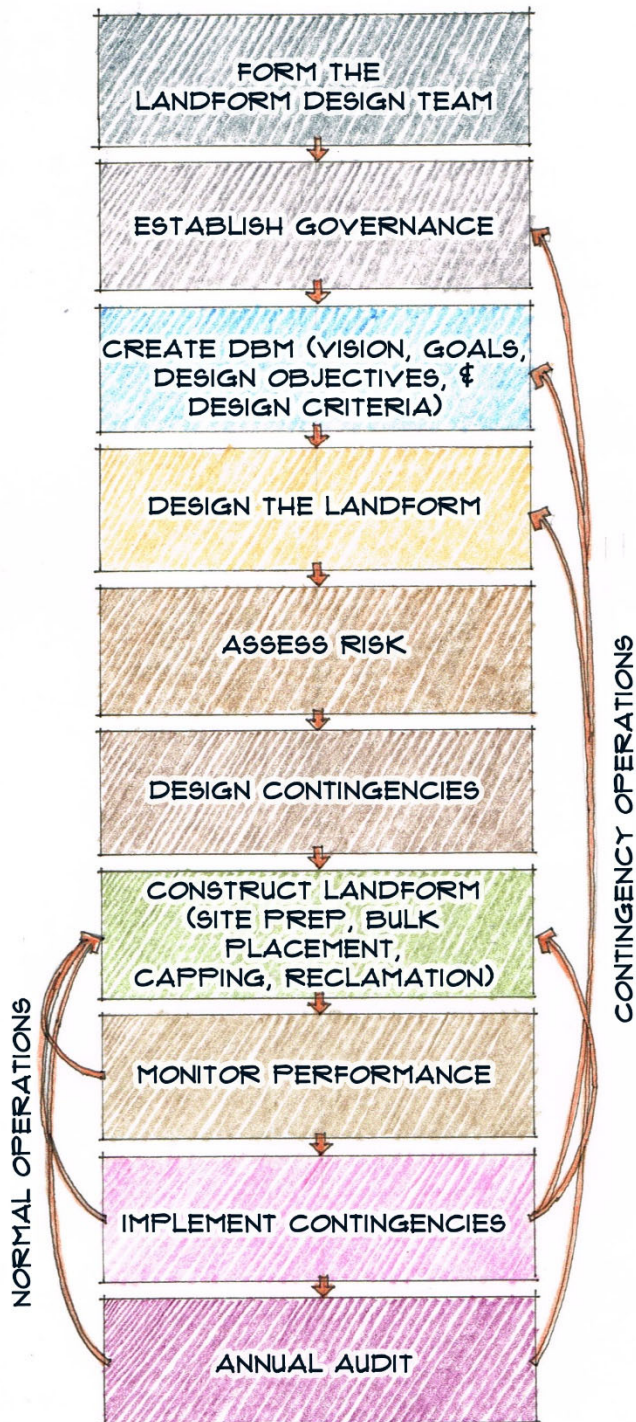
<sup>4</sup> *EPEA - Environmental Protection and Enhancement Act*

<sup>5</sup> MFSP – Mine Financial Security Plan

In AB and BC, numerous operating coal mines (e.g., Teck Coal's Elk Valley mines; BC), proposed coal mine developments (e.g., Tent Mountain; AB, Michel Creek; BC), and mines in suspension (e.g., Grande Cache; AB) have comprehensive SeMMPs; these are to be considered in the realm of "standard practice".

See our recommendation at the end of the first question above.

## 9. Summary / main messages



- Elevated selenium in water downstream from coal mining is a serious issue, which can potentially have major impacts on the aquatic animals (fish, aquatic birds) and the sustainability of coal mining.
- Selenium needs to be managed and regulated, and both of these activities should be informed by the emerging science.
- Selenium management is a key aspect of landform design, mine design, construction, operation, reclamation, and aftercare.
- Selenium management should utilize a multi-pronged approach, which includes good design, the application, implementation and integration of various mitigation and treatment strategies and technologies, and a comprehensive monitoring program developed as part of the overall management system.
- Collaboration related to selenium management with all stakeholders is necessary to achieve a common vision and common goals.
- Selenium is the focus of this presentation. However, selenium management is just one of many environmental issues that need to be identified, designed for, and managed. The integration to achieve the vision, goals, and objectives for operating and reclaimed mine sites is the focus on landform design (LDI 2021), and a major focus of Rocky Mountain coal mining, more generally.

Figure 2. Landform design process – selenium management is one aspect of this work. There are parallels (but also crucial differences) with adaptive management.

## 10. Literature cited

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